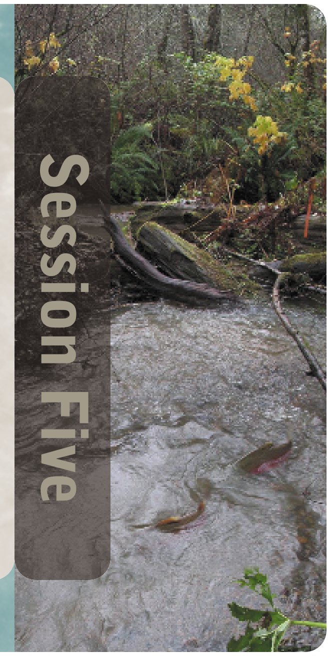
Upgrading and installation of fish passages and fish screens, offstream water storage

Fish Protection Facility Cost Drivers and Considerations: Why Are Costs All Over the Board?



DARRYL HAYES, Consultant
CALFED Bay Delta Program
2485 Natomas Park Drive, Suite 600
Sacramento, CA 95833
dhayes@ch2m.com

ABSTRACT

Fish screens are physical barriers designed to prevent fish entrainment and/or impingement at diversions, while allowing water to pass. This paper discusses fish screening projects and the variables that dictate project costs.

INTRODUCTION

The State of California is currently expending millions to fund fish screening projects through the CALFED Bay Delta Program, through the Central Valley Project Improvement Act (CVPIA), through the California Department of Fish and Game (CDFG), and through several bond acts. Much of the money has been used for priority projects, including those on the largest streams and in the most critical habitat. Many smaller facilities have also been constructed.

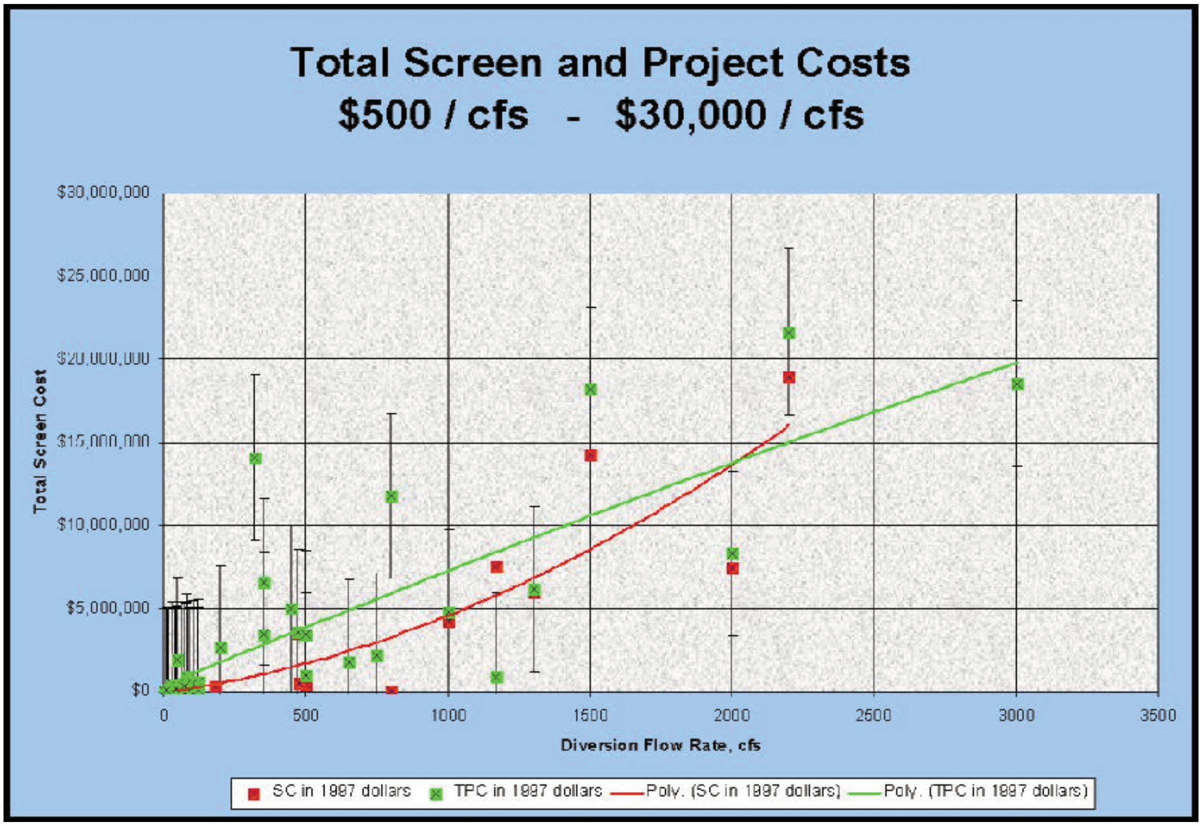
Screen project costs vary widely, and there are many different elements that make up a project. The fish screen itself is often a relatively small portion of the total project, which will also include pumps, cleaning systems, site work, and other aspects of the facility. It can be quite difficult to separate the cost of the screening portion of the project from the total project costs. For example, screen costs may only account for $5,000 of a $100,000 job. It is not easy to make general estimates that will hold true for a variety of projects.

COST COMPARISONS

Evaluating screen project costs on a large scale will necessitate comparing many different projects. If we are trying to estimate the costs of past projects, it is important to know how the costs were reported in the past, so that cost comparisons are consistent. Figures 1 and 2 show some of these comparisons. Figure 1 is a chart of screen cost as a function of the diversion flow rate for screen and total project costs in California, and Figure 2 shows cost as a function of diversion flow rate for recent large facility screen costs.

When making comparisons like the ones above, it is important to keep in mind the following questions. Would the same facility be designed today? Does the

Figure 1. Total screen and project costs (primarily California projects)



project include the support facilities necessary to operate and maintain the facility? Does the project include relocation or major site work? Does it include upgrades to old facilities? Does it include exposure to flood events? Is it an on- or off-river facility? Does the design account for water level fluctuations and operations?

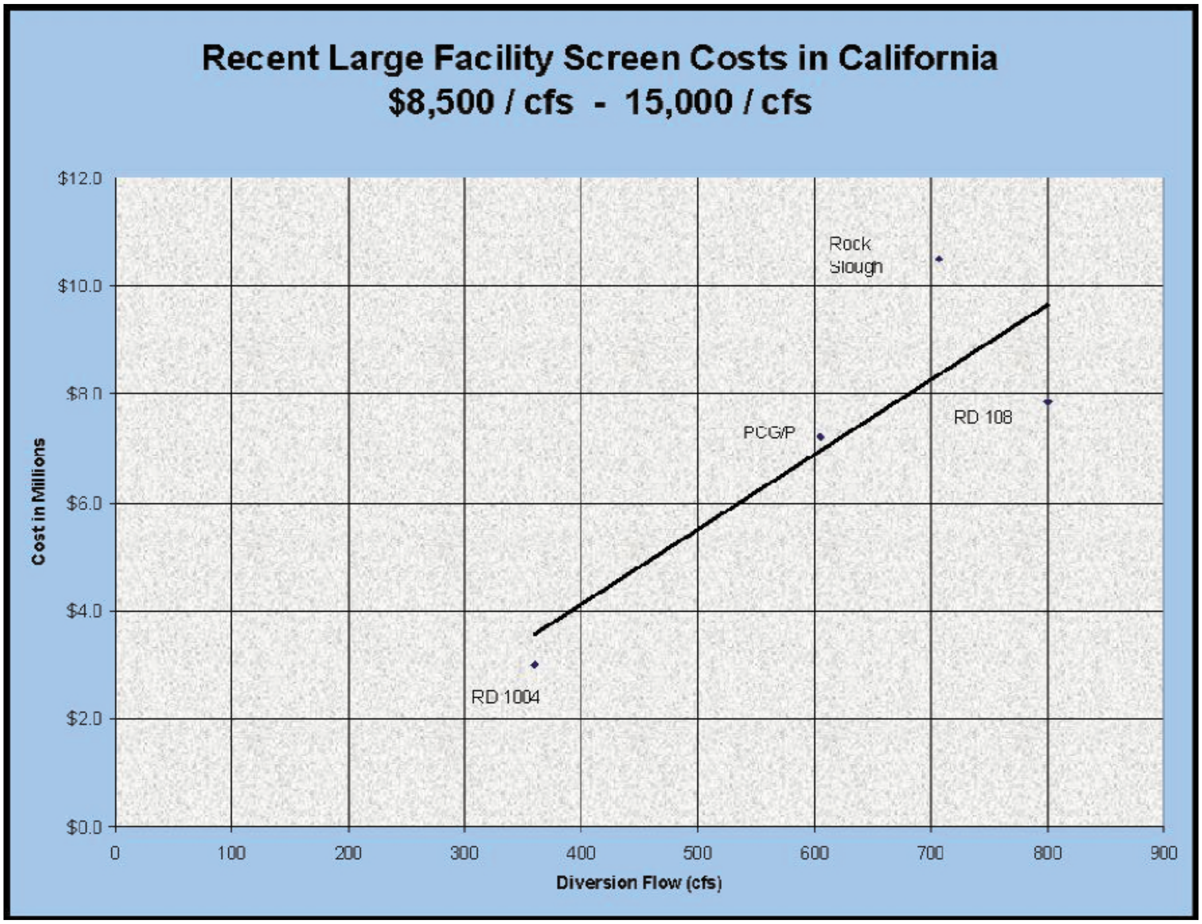
Project Planning: Issues and Considerations

Many different issues must be considered when planning a fish screen project, and each has an impact on the final project cost. The major planning categories include: 1) site development, 2) local community issues and concerns, 3) hydrology and channel morphology at the site, 4) project design and construction, 5) future operation and maintenance of the facility, and 6) environmental documentation and permitting.

Environmental permitting can limit the facility options. For example, habitat can restrict activities and prevent work in that area. Another conflict can arise if other restoration actions in the area have goals that do not integrate well with a fish screen facility. For example, a watershed group might want to establish a meander in a river system. This effort will likely be contrary to putting in a screen facility, which could require the establishment of a hard point at the diversion.

The environmental permitting process is currently difficult and cumbersome and needs to be streamlined for many fish screen and restoration projects. Successfully getting through the process is very expensive and often generates a lot of confusion. In California, through the CVPIA Anadromous Fish Screen Program, an effort has been made to centralize the permitting process by

Figure 2. Recent large facility screen costs in California



assigning one program representative to work through the process with the applicant. This has been fairly successful, especially on the smaller-scale projects. There have been recent changes to some of the Army Corps of Engineers permitting processes (including smaller pumped diversions into the nation-wide permit) that have been helpful.

FISH SCREEN CRITERIA

Some of the most important causes of escalating screen costs are increasingly restrictive juvenile fish screen criteria. These criteria include the following:

- *Screen openings*: The trend is toward smaller and smaller openings. For salmon and steelhead fry protection, the currently required slot size is (profile bar) 1.75mm. The smaller the opening is, the more difficult it is to keep the screen clean, and the more expensive to maintain the facility.

- *Approach velocity*: This criterion depends on the location of the screen. In the upper northwest part of California, there is a 0.33 feet per second approach velocity (on cross screen area), while in the Sacramento River Delta the requirement is 0.2 feet per second. The reason for the difference is primarily due to the fact that the Delta criterion includes fish other than salmonids.

- *Sweeping velocity*: The criteria can require screens to be located away from existing diversion locations.

• *Bypasses*: Whether or not a screen bypass is necessary must be determined, and can have a significant impact on the final project cost.

• *Screen hydraulics*: Uniform approach velocities require additional hydraulic control.

It is crucial not to let the screen criteria get in the way of fish protection. We must ask ourselves if we are really more interested in protecting the criteria instead of the fish. For instance, a screen may be designed for the most restrictive criteria and fish life stage, even though the probability of that species occurrence in an area is minimal. Following criteria to the letter can drive the cost of the screen facilities up, which in some cases may make it impossible to actually implement the design. In those cases, the fish lose.

There are times when we should consider alternative screen designs, if a site-specific case can be made. However, there is often resistance to alternative designs, due to either precedence issues or less than optimal protection to fish, albeit small. Alternative designs such as Coanda screens (overflow screens) or high velocity screens may be good solutions to particular design problems.

Design flow rate can be an important consideration in screen sizing. In the negotiation between the diversion owner and the agencies involved, the cost may be driven much higher than the diverter can afford in an attempt to design the screen for maximum flow. It may be much more realistic to design for 95% flow instead of 98% or 99%, because this flexibility may mean the difference between building and not building the screen.

The cost of a facility can also be driven by the research opportunities. When research is conducted, it is important to determine who should share the cost and who will benefit from the knowledge gained. Research costs often end up being the responsibility of the irrigation district, but districts are typically reluctant to pay for research because they will not directly benefit from much of what is learned. The CALFED Bay Delta Program however is very interested in the scientific benefits of monitoring and has shared in some of those costs.

Figure 3. Hydraulic and biological relationships near screens (lab research)

Laboratory research can provide valuable insight and potentially reduce future screen costs through an understanding of the biological and hydraulic interactions at screens. Figure 3 shows a research project simulating a long and continuous screen that looks at a

Figure 4. CCWD Los Vaqueros pumping plant intake sampling net (field research)

lot of different fish species to investigate the different relationships between approach velocity and sweeping velocity. Research like this can go a long way in helping us understand whether a criterion can be applied to many different species as well as many different sizes of fish.

Field research is also important. Some of the larger facilities provide valuable opportunities for monitoring screen efficiency and success. Figure 4 shows the Contra Costa Water District's Los Vaqueros pumping plant in the Delta. Slots were designed into the facility so monitoring activities could be done. However, the additional concrete and steel needed to construct the slots increased the cost of the project. For this facility, much of the work is being carried out by CDFG, which will be reimbursed by the diverter.

RETROFITTING EXISTING FACILITIES

It can be cost-effective to retrofit existing pumping plant or diversion facilities with screens, but it depends on several conditions, each of which can drive project costs significantly:

- *Pump Adequacy*: The pumps must be able to overcome the headloss caused by the screens.

• *Electrical Requirements*: Almost all screens today require an automatic cleaning system and an electrical power supply to keep things going. We have a project in the Delta marsh area, on an island with no power. It would cost $80,000 to string underwater cable and bring power to the site. On this particular project, they actually used solar panels and batteries, but those still add considerably to the price of the project.

• *Structural Adequacy*: Old pumps typically sit on old piles or structures. The new screens must be supported with them, or most often need to be replaced.

• *Relocation Issues*: Poor hydraulics, morphology pump depth, or operations disruptions may necessitate moving the site. In California, the CVPIA may pay for relocation if it will be beneficial to the fish or screen function. Relocation costs can be significant since it can involve new research, engineering, and all new facilities.

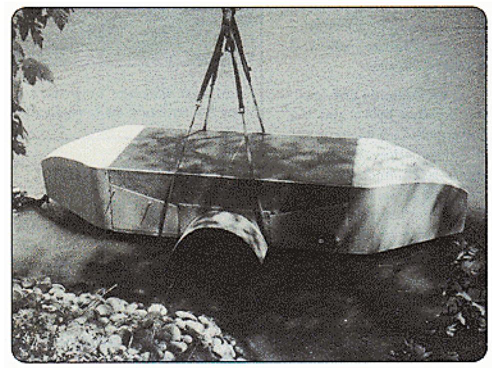
• *Operational Disruptions*: If the project involves a large screen facility and the work takes two construction seasons (typically our construction seasons are during irrigation seasons), it can be very difficult to plan for optimal project timing. Significant costs can be incurred attempting to stage work so as not to disrupt our facilities.

COST CONSIDERATIONS BY PROJECT PHASE

Design Cost Drivers

Often the biggest determinants of project cost are the river conditions, including debris, water level and sedimentation. Facilities in flood prone areas can be problematic and handling this debris and sediment is a major cost for almost all facilities in California. Planning for good hydraulic performance is crucial to ensure that the facility is able to operate under a wide variety of river conditions. This planning drives costs up, but in the end makes for much more cost-effective and successful facilities.

Figure 5. Universal stream bottom retrievable fish screen



There was a time when standardizing screen designs seemed to be a great idea. If a “universal” screen worked, unit cost of the facilities might go down. For instance, one such design looked feasible at a total installation cost of around $2,000 per cubic feet per second (CFS). This screen, the universal stream bottom retrievable fish screen, is shown in Figure 5. The idea was to put them in rivers and lakes or wherever anyone needed a diversion. The screen could float and be retrieved. However, because the early installations did not take into account river morphology or sediment issues, this standardized screen has not had a “universal” application.

As discussed above, building in operational flexibility is key to successful projects, even though they may be more costly. Fish facilities often cost more today because we design them to be able to handle a much broader range of conditions. For example, in many cases unsuccessful fish ladders do not work because they are built to operate in only a narrow range of flows and water levels and are unable to effectively manage debris. Figure 6 shows a facility that has been built to work in a variety of conditions,

Figure 6. Operational flexibility (adjustable overflow gates allow proper ladder hydraulics with 3-foot pool fluctuation)

with automatic adjustable gates that can deal successfully with water-level fluctuation. Figure 7 shows a screen facility that includes a brush cleaner on an inclined plate and a sediment trap, which are both features that increase the screen's ability to function under varied conditions. Not surprisingly, facilities such as these are more expensive than simpler facilities.

Construction Cost Drivers

Often, construction methods can be limited, driving project costs. There are certain times, for example during migration season, that piles cannot be driven. At some sites construction may be restricted to certain hours during the day due to noise restraints. These limitations can dramatically increase the project cost if it is necessary to lengthen the construction period in order to accommodate the restrictions. It is very important to plan for these construction contingencies early in the project, in order to minimize the effects on cost.

Construction in large rivers can also drive costs. Figure 8 shows construction of the Princeton Cordora Glenn-Providence

Figure 7. RD 1004's operational flexibility helps insure project reliability in extreme conditions

Irrigation district. It was necessary to keep the entire project area dry during construction despite extreme flow events in the Sacramento River. There were tremendous pumping and de-watering costs incurred for the project. Figure 8 shows just how deep the structure is — the water level outside the project area is about 30 feet.

Operations and Maintenance: Costs

The costs associated with project operations and maintenance are usually significant and are often overlooked. It is rare for project planners to spend enough time considering who will operate and maintain the facilities. Most fish screen projects require control and cleaning systems that operate almost continually, especially during the irrigation season.

In addition, there is a huge need to maintain the equipment protection systems, including corrosion protection and replacing

Figure 8. PCG-P's facility behind significant cofferdam

worn parts. Maintaining these systems requires material and staffing.

Following is a more detailed discussion of some of the life cycle costs that are necessary to maintaining screen facilities. These factors and costs must be anticipated when a project is planned.

Underwater Access

Many projects in the river require divers to inspect the facilities periodically. The labor cost for this service generally runs about $1,500 a day. There has been a movement in California to report the results of required inspections, which is a cost that one of the participating stakeholders will have to bear. In California, the National Marine Fisheries Service (NMFS) keeps some records on screen facilities in order to develop histories that will aid in determining the track record of the facility.

Screen Cleaning

Figure 9 shows an airburst-cleaning screen. The advantage of this type of cleaning system is that there are no moving parts underwater. However, the screens still require a significant amount of work in the off season. Someone has to scrub them periodically, which requires time and money. Figure 10 shows some screens with bristles that were not maintained, allowing growth behind the screen to get packed in. If screens are not regularly monitored and maintained, weak spots will develop that will eventually affect the structural integrity of the screen.

Figure 9. Airburst screen cleaning system

Figure 10. Improperly cleaned and maintained screen

Figure 11 shows a screen that is completely packed with debris. Nothing will be able to pass through this screen. Figure 12 shows a water backwash system that has a spray nozzle to internally spray the backside of the screen just enough so that the water outside will push the material away. This type of cleaning system typically works

Figure 11. Debris-clogged screen

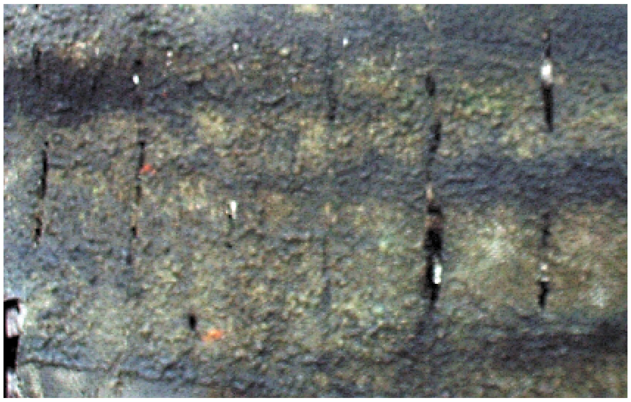


Figure 12. Water backwash cleaning system with clogged spray nozzle

well unless debris is allowed to accumulate in the nozzles (i.e. lack of filter), which will eventually lead to the failure of the facility.

Figure 13 shows a screen that had to be taken out of the stream shortly after it was put in. In an attempt to install screens inexpensively, several installations were installed with lightweight screens and minimal engineering at a cost of $1,000–2,000. In brief, lightweight irrigation screens were applied to the Sacramento River. However, the river has tremendous debris loads and other conditions that the screens were not designed for. These facilities had no failsafe system, no emergency blowout panels, relief systems, or pump shutoffs, just a screen strapped onto the end of a pipe. In Figure 13, a backwater

Figure 13. Andreotti fish screen 9/96 (collapsed screen)

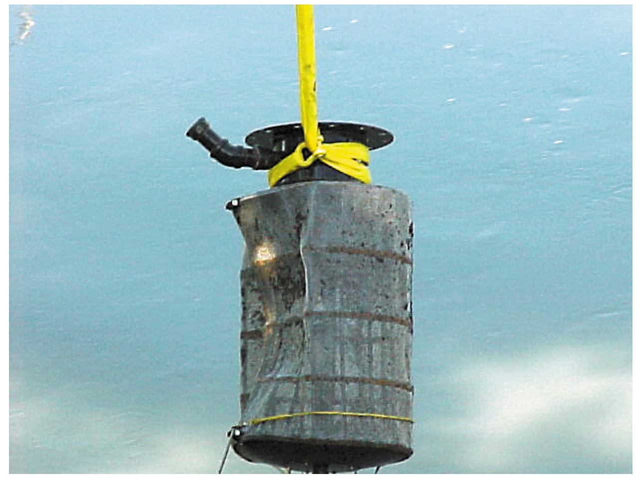


Figure 14. Butte Creek Farms screen 4/12/99 (screen failure)

system was ineffective and failed in just a matter of minutes due to the suction load on the screen. Figure 14 shows another screen with a similar clogging failure due to poor cleaning.

Corrosion

Figure 15 shows a facility built in slightly brackish water. This system worked well in another setting, but here there were issues with electrolysis and dissimilar metals at this site. In fact, a stainless steel structure was eating away at the screen because of the

Figure 15. Corroded screen — dissimilar metals and poor water quality (outside view)

Figure 16. Corroded screen (inside view)

poor water quality in the stream. Interestingly, nobody recognized that this was going on until the diving inspector announced that there was a big hole in the

Figure 17. Grit damage to the screen cleaning system

screen. This experience underlines the importance of regular inspections, reporting requirements, and accountability for proper screen functioning. Figure 16 shows the same screen as in Figure 15, but from the inside. There is clearly very little fish protection provided by a screen in this condition.

In Figure 15, it is possible to see stripes on the screen of an internally backwashed system which uses spraybars to do the backwash. This system is effective where the nozzle sprays, but not elsewhere. This leads to the striping pattern, which is caused by poor cleaning. Over time, even self-cleaning systems require cleaning maintenance.

Sedimentation

In Figure 17, it is possible to see the damage caused by suspended sand on the shaft of an internally backwashed screen. This type of system has sealed bearings inside the screen; however, sand is able to enter these supposedly sealed bearings, which eventually caused the system to stop functioning.

Operations and Maintenance: Lessons and Considerations

It is of primary importance that operations and maintenance be cost-effective for either the landowner or the agency. Someone

Figure 18. Retrievable cylindrical screen (two views)

must pay for them and if it is left up to landowners, as it is in California, operations and maintenance may be neglected. For example, if there is a hole in their screen but the landowner still gets their water, they are probably not going to complain. Unfortunately, the fish ultimately pay for a lack of attention to the screens.

Retrievability

It is very important to inspect screens periodically, which means that the screens should be retrievable. It is best to put screens in the water that can be removed during the non-irrigation seasons. These features will increase the cost of the project, but the increased life expectancy of the screen will usually more than compensate for higher initial costs. The screens will last at least two to three times as long and will be more effective for the landowners and the fish. Figure 18 shows two views of a retrievable cylindrical screen that is easily removed from the water for monitoring and maintenance.

Providing Access

Many facilities in small creeks are difficult to access. For example, it may be difficult to reach them during a rain event. Access for maintenance or inspection must be factored into the cost of these facilities; without access, the maintenance cannot happen.

Fail-safe Back-up Systems

These can be as simple as alarms or pump shut-offs. In one project in the Suisun Marsh area in California, they have put into place a very effective facility monitoring system. Telemeters indicate how the facility is working: when it is operating, whether or not the brushes are working, and other relevant data. This information is sent to a central office so they can obtain a status report and know whether to send someone out to the facilities. Back-up systems are very cost effective and preventative to add to a project.

Brush Cleaning

Generally, brush cleaning is a better method than air or water systems. The screens have to be scrubbed, often manually, but the result is a cleaner and more effective screen. Once again, the expenditure of a higher initial cost is repaid later in terms of the duration and proper functioning of the screen.

Figure 19 shows a small screen that is an example of the best screen technology that

Figure 19. Small screen state-of-the-art

has been developed. Screens like this are being used to replace older failed screens. This screen has a capacity of about 15–20 CFS. This installation replaced a year-old facility that originally cost a little over $25,000. This new screen cost $100,000, and it still looks brand new after a year. This screen is retrievable, making inspection, cleaning, and maintenance much easier. This screen incorporates all the lessons that we have learned over the years. It has brush cleaning and internal baffling for hydrologic control, which creates an even distribution of flow through the stream. The even distribution of flow also makes for a cleaner screen, because debris is more likely to accumulate where the flows are uneven. The screen is made of wedge-wire, which has proven to be the most durable and easy to clean material. It is more expensive, but is reliable and durable, providing better fish protection.

SCREEN PROGRAMS AND COST INFORMATION RESOURCES IN CALIFORNIA

- CVPIA Anadromous Fish Screen Program (Bill O'Leary, USFWS)
- CALFED Ecosystem Restoration Program (Terry Mills, CALFED)
- IEP Central Valley Fish Facilities Coordination Team (Rich Wantuck, NMFS)
- NRCS Family Water Alliance Screen Program (Sue Sutton, FWA)

Listed above are a number of resources for more information on costs. The CVPIA Anadromous Fish Screen Program is a clearinghouse for quite a few fish screening projects now in California. For example, an irrigator who wants to apply for these funds does not need to approach several different funding sources and coordinate several different programs. Instead, they can apply only once and have access to many different funding sources.

There are several other programs that are not included in the CVPIA program, although most coordinate with each other. One of these is the CALFED Ecosystem Restoration Program, which funds a lot of screening facilities and has access to some funds that CVPIA does not. Through 1999 CALFED has funded over $40–50 million on screening projects, primarily on the larger facilities.

In California, small screens have been funded through the Family Water Alliance (FWA) at the Natural Resource Conservation Service (NRCS). They focus on the smaller screen facilities, while CALFED and CVPIA concentrate on the larger facilities. A fish facilities coordination team in California serves as a very effective forum in which to coordinate efforts, collaborate on facilities planning, and share the many lessons learned.

One other source of information on screening projects is the Watershed Report put out by the CVPIA. This document shows facility costs on a tributary basis. It is available on CD-ROM.

Central Valley Project Improvement Act Tributary Production Enhancement Report. A draft report to Congress on the feasibility, cost, and desirability of implementing measures pursuant to subsections 3406(e)(3) and (e)(6) of the CVPIA. USFWS. Sacramento, CA. May 1998.